REMARKS

Applicants thank the Examiner for the courtesy extended to Applicants' attorney and the assignee's representative during the interview held December 1, 2004, in the above-identified application. During the interview, Applicants' attorney explained the presently-claimed invention and why it is patentable over the applied prior art, and discussed other issues raised in the Office Action. The discussion is summarized and expanded upon below.

The rejections under 35 U.S.C. § 103(a) of Claim 9 as unpatentable over U.S. 6,146,467 (Takaishi et al), and of Claims 1-7 and 10-16 as unpatentable over Takaishi et al in view of U.S. 5,637,151 (Schulz), are respectfully traversed.

The present invention relates to a cleaning method for cleaning a surface of a substrate for a device in a process for producing e.g. a semiconductor device or a display device. Particularly, it relates to a method for cleaning a surface of a substrate, whereby both metals and fine particles as contaminants on the substrate can be removed in a short time to highly clean the surface of the substrate.

As described in the specification under "Background Art", beginning at page 1, line 12, in the cleaning of substrates to remove metal contaminants and particle contaminants, such as from substrates to be used in semiconductor devices, it is known to use an aqueous alkaline solution for what is known as SC-1 cleaning or APM cleaning for removal of particle contaminants, and an aqueous acidic solution for what is known as SC-2 cleaning or HPM cleaning, for removing metal contaminants. The combination of SC-1 cleaning followed by SC-2 cleaning is known in the art as RCA cleaning. Further, in order to remove metal contaminants firmly chemically bonded to Si or SiO_2 on the substrate surface, or a very small amount of metal contaminants taken into the interior of the surface layer of the substrate, it is effective to etch the surface layer of the substrate with a dilute hydrofluoric acid aqueous solution having a hydrofluoric acid content of from about 0.25 to 1 wt%, known as dilute

hydrofluoric acid cleaning. Such cleaning has been used in the prior art after SC-1 cleaning or after SC-2 cleaning, or between SC-1 cleaning and SC-2 cleaning. Such cleaning methods have been carried out in both batch type cleaning apparatus and sheet system cleaning apparatus. The batch type apparatus is capable of treating a large number of substrates per unit time, but suffers from problems of the apparatus being large and so-called redeposition of contaminants, i.e., crosscontamination among substrates. On the other hand, the sheet system apparatus is free from crosscontamination and the apparatus is small, but only a relatively small number of substrates can be treated per unit time. In addition, during the usual cleaning treatment for from 1 to 5 minutes by means of dilute hydrofluoric acid cleaning, using an aqueous hydrofluoric acid solution having a concentration of about 0.5 wt%, the substrate surface, such as an SiO_2 film or the like, will be etched by at least 10 Å, whereby the dimensional precision of the device on the substrate surface will be impaired. Other problems exist, such as particles likely to deposit and contaminate the hydrophobic Si surface exposed by etching, and a stain-like soiling which forms when a water drop remaining on a hydrophobic surface dries up, i.e., a so-called watermark. In order to control such etching of SiO_2, a cleaning method has been proposed using the same cleaning time, but wherein the hydrofluoric acid concentration is extremely reduced, such as to a level of 10 wt ppm of hydrofluoric acid in pure water. However, at such a low concentration, the cleaning time is required to be about five minutes, thereby reducing production efficiency. In addition, where this method is applied to a sheet cleaning apparatus, a large amount of cleaning agent will be required, and accordingly, a large amount of acid waste liquid will be formed.

The presently-claimed invention addresses the above-discussed problems of the prior art. Specifically, the invention herein requires a relatively short time, allows for removal of both particle contaminants and metal contaminants, and substantially reduces cross-

contamination and dimensional change due to etching. Specifically, as described in the specification in the paragraph bridging pages 7 and 8, Applicants found unexpectedly that rather than cleaning for a long time by means of an extremely diluted hydrofluoric acid aqueous solution, Applicants were able to achieve the desired effect by controlling the hydrofluoric acid concentration and the cleaning time to be within specific ranges, respectively, and to satisfy a particular relationship.

Thus, as recited in Claim 1, the invention is a method for cleaning a surface of a substrate, which comprises at least the following steps (1) and (2), wherein the step (2) is carried out after carrying out the step (1):

Step (1): A cleaning step of cleaning the surface of the substrate with an alkaline cleaning agent containing a complexing agent, and

Step (2): A cleaning step employing a cleaning agent having a hydrofluoric acid content C (wt%) of from 0.03 to 3 wt%, wherein the cleaning time t (seconds) of the substrate with said cleaning agent is at most 45 seconds, and C and t satisfy the relationship of $0.25 \leqq tC^{1.29} \leqq 5$.

Also, as recited in Claim 9, the invention is also a method for cleaning a surface of a substrate, which comprises at least the following steps (2) and (3), wherein the step (3) is carried out after carrying out the step (2):

Step (2): A cleaning step employing a cleaning agent having a hydrofluoric acid content C (wt%) of from 0.03 to 3 wt%, wherein the cleaning time t (seconds) of the substrate with said cleaning agent is at most 45 seconds, and C and t satisfy the relationship of $0.25 \leqq tC^{1.29} \leqq 5$, and

Step (3): A cleaning step of cleaning the surface of the substrate with an alkaline cleaning agent.

Regarding the present inventions, Applicants describe the following, in the paragraph bridging pages 8 and 9 of the specification:

> As a result of a further study, it has been found that by combining the step of cleaning the substrate surface with an alkaline cleaning agent with the above-mentioned cleaning step by means of an aqueous hydrofluoric acid solution i.e. the step of cleaning the substrate surface for a specified time or less by means of a cleaning agent having a hydrofluoric acid content of a specific level or more, wherein the hydrofluoric acid concentration in the cleaning agent and the cleaning time satisfy a specific relationship, particle contaminants and metal contaminants on the substrate surface can together be removed in a very short time, and an excellent effect can be obtained such that there will be no substantial problem such as a watermark, re-deposition of particles or a dimensional change due to etching, and the present invention has been completed.

The efficacy of the present inventions is demonstrated by the comparative data in the specification and its superiority to the methods of the above-discussed prior art. Compare, for example, Example 13 and Comparative Example 9, described in the specification beginning at page 50, line 7, wherein both t and C are within the terms of the present Claim 1 but the relationship $0.25 \leqq tC^{1.29} \leqq 5$ is satisfied for Example 9 but not satisfied for Comparative Example 9. As Table 3 at page 51 of the specification indicates, etching was good for Example 9 but bad for Comparative Example 9. Thus, contrary to the suggestion made by the Examiner during the above-referenced interview, the above relationship is not necessarily satisfied, even if t and C are satisfied.

Takaishi et al discloses a multi-step cleaning method comprising a step 11 for oxidizing-reducing a semiconductor substrate, a step 12 for oxidizing the oxidized-reduced semiconductor substrate, a step 13 for reducing the oxidized semiconductor substrate, a step 14 for rinsing the reduced semiconductor substrate, and a step 15 for re-oxidizing the rinsed semiconductor substrate (column 2, lines 41-48), wherein step 13 is carried out in a mixed solution of hydrofluoric acid with an organic acid or with the salt of an organic acid (paragraph bridging columns 3 and 4), and wherein the concentration of the hydrofluoric acid

is from 0.005 to 0.25 wt%, and most preferably 0.05 to 0.10 wt% (column 4, lines 3-6). Step 13 is carried out in order to remove metal impurities and particles brought into the oxide film at step 11 and step 12 by dissolving the oxide film (column 3, lines 44-46). In all the examples (referred to as Embodiments therein), step 13 is carried out with a solution containing 0.05 wt% of hydrofluoric acid and for five minutes (column 5, lines 42-48). No other cleaning times are disclosed or exemplified. Moreover, since new Claims 18-21 require a minimum hydrofluoric acid concentration greater than the 0.05 wt% exemplified by Takaishi et al, they are separately patentable.

Schulz discloses a method for reducing metal contamination of silicon wafers during semiconductor manufacturing, which involves inclusion of a complex building agent, such as EDTA, during an SC-1 cleaning step.

Takaishi et al does not render the subject matter of Claim 9 unpatentable. The Examiner assumes that the present invention, in essence, is simply reversing the alkaline cleaning step and hydrofluoric acid cleaning step of Takaishi et al. However, it is not clear why one skilled in the art would reverse any of the steps in Takaishi et al, since it appears to be a requirement therein that steps 11-15 be carried out in the order disclosed. Indeed, as discussed above, step 13 is carried out because of the results obtained from carrying out steps 11 and 12. Rearranging the steps of Takaishi et al would frustrate Takaishi et al's purposes. Moreover, and perhaps more significantly, even if the steps were reversed, Takaishi et al neither discloses nor suggests a treatment time of at most 45 seconds (5 minutes being the only treatment time disclosed), or that the hydrofluoric acid content and the treatment time satisfy the relationship recited in the claims.

Nor does the combination of Schulz and Takaishi et al render unpatentable the subject matter of the remaining claims. Thus, even if a complexing agent were included in the

alkaline cleaning step of Takaishi et al, i.e., step 11, the above-discussed deficiencies of Takaishi et al would not be removed.

For all the above reasons, it is respectfully requested that the rejections over prior art be withdrawn.

The rejection of Claims 8 and 17 under 35 U.S.C. § 112, second paragraph, is respectfully traversed. During the above-referenced interview, Applicants' attorney showed the Examiner above-amended Claim 8. The Examiner appeared to agree that such an amendment would overcome this rejection. Thus, the rejection is now moot in view of the above-discussed amendment. Accordingly, it is respectfully requested that it be withdrawn.

All of the presently-pending claims in this application are now believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to pass this application to issue.

Respectfully submitted,

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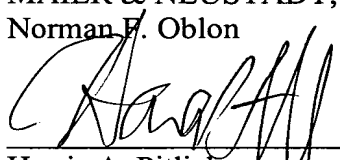

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